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Effect of glucose infusion on the maternal and fetal acid-base equilibrium during labor*

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1 Introduction

The measurement of acid-base equilibrium in the scalp capillary blood is a useful semiotic method for the evaluation of fetal vitality during labor. This technique, made possible by SALING [14], has been applied in several studies of fetal homeostasis [3, 7, 8, 9, 11].

In a study of glucose metabolism and maternal and fetal acid-base equilibrium, FEIGE et al. [5] demonstrated interesting correlations between glycemia and blood gases in the two compartments. They concluded that the increase in maternal glucose levels during labor was the result of glycogenolysis which was due to phosphorylase activation in response to increased catecholamine levels. Fetal glycemia, on the other hand, was probably either due to the transplacental passage of maternal glucose or glycogenolysis as observed in the mother.

Glucose loading has been widely used to assess diabetic patients or to diagnose possible pathologies during gestation, but few studies of this type have been carried out during labor. The objective of the present research was to study the maternal and fetal acid-base equilibrium during labor under glucose overload test conditions.

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Curriculum vitae

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2 Material and methods

The material consisted of blood samples from 20 clinically normal parturients and their fetuses who had been admitted to the Clinical Hospital of the Medical School of Ribeirão Preto, University of São Paulo. The blood samples were collected from patients in labor who had been fasting for at least 6 hours. The patients were considered to be clinically normal when thorough physical examination and complementary routine prenatal tests (hemogram, urine sedimentoscopy, blood typing, WASSERMANN, colposcopy, colpocytology, parasitology of feces, glycemia and immunological reaction for CHAGAS' disease) showed no evidence of concomitant disease nor of disease caused by

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the gestational cycle. The gestational age, calculated from the first day of the last menstrual cycle, varied between 38 and 42 weeks.

Patients with a family history of diabetes and an obstetrical history of fetal macrosomy (weight of more than 4,000 g) were excluded from the samples. Also excluded were the cases in which the pH of the capillary blood collected from the scalp of the fetus before glucose infusion was less than 7.25 and the cases in which the pH of the umbilical artery blood was less than 7.22 (16) at birth and/or the APGAR score was less than 7 during the first to fifth minute of life.

The samples of maternal peripheral blood were obtained by venous puncture into heparinized syringes from the forearm contralateral to that chosen for glucose infusion. Contact with air was avoided, as well as prolonged constriction of the arm. The first blood sample was taken before glucose infusion, and further collections were made by separate punctures at intervals of 15, 30, 45 and 60 minutes after the infusion.

Capillary blood was collected from the fetal scalp during labor by the technique described by SALING [14] before glucose was administered to the mother and afterwards at intervals of 15, 30, 45 and 60 minutes.

The method of glucose infusion was as described by AMATUZIO et al. [1], whereby **50 ml of 50% glucose was administered intravenously for a period of 4 minutes after collecting the first sample.** The biochemical parameters of the acid-base equilibrium were measured with a pH meter (pH gas analyzer, Model 213 and 214, Instrumental Laboratory Corporation). The data was analyzed statistically by WILCOXON's non-parametric test of with pairing [15].

3 Results

Tab. I shows the median, 1st and 3rd quartile values for the pH, pCO_2, pO_2, HCO_3, CO_2, total base deficit and BE of maternal peripheral venous blood. No statistically significant differences ($p > 0.05$) were observed between the values obtained before and after glucose infusion for the various parameters at the different times studied.

Tab. II shows the median, 1st and 3rd quartile values for the pH, pCO_2, pO_2, HCO_3, total CO_2 and BE of capillary blood from the fetal scalp. The results obtained before and after glucose infusion showed pO_2 differences at the 30 ($p < 0.05$), 45 ($p < 0.05$) and 60 minute ($p < 0.01$) time points (Fig. 1). The total CO_2 values were significantly different ($p < 0.05$) at 60 minutes after glucose infusion (Fig. 2). The remaining parameters (pH, pCO_2, HCO_3 and BE) did not vary significantly at any of the time points studied.

4 Discussion

The study of carbohydrate metabolism is becoming more important as the use of glucose to treat intrapartum fetal distress is accepted by an increasing number of researchers. Furthermore, the most reliable index for the evaluation of fetal well-being in utero is the pH, which leads the researcher to look for possible correlations between glycemic levels and the parameters of fetal acid-base equilibrium during labor. The studies carried out to date on alterations in the maternal and fetal acid-base equilibrium brought about by glucose infusion into the mother have yielded contradictory results, especially in the presence of fetal distress. When, on the one hand, improved metabolic fetal conditions mainly due to pH elevation [13] have been reported, increased metabolic acidosis due to the increase in acid radicals released under anaerobic glycolysis conditions has also been reported [4, 12].

It has been reported that in the case of fetuses showing no clinical or laboratory evidence of intrapartum distress, glucose infusion into the mother has not significantly modified the pH and blood gases values in the capillary blood from the scalp [2]. **In the present study, however, significant differences in pO_2 and total CO_2 have been observed in the fetal capillary blood.** The other fetal parameters (pH, pCO_2, HCO_3 and BE) and the maternal blood gases showed no significant differences. **These findings did not permit us to state that glucose infusion may be responsible for the alterations found,** since it is known that pO_2 tends to drop as labor progresses, while total CO_2

Tab. I. Median (M), first (Q_1) and third (Q_3) quartile values for the parameters of acid-base equilibrium (A.B.E.) in maternal peripheral blood. Samples collected after fasting and at intervals of 15, 30, 45 and 60 minutes after glucose infusion.

A.B.E.	Fasting			15 min			30 min			45 min			60 min		
	M	Q_1	Q_3	M	Q_1	Q_3	M	Q_1	Q_3	M	Q_1	Q_3	M	Q_1	Q_3
pH	7.425	7.403	7.471	7.427	7.390	7.464	7.433	7.408	7.483	7.456	7.400	7.479	7.460	7.429	7.496
pO_2	37.1	32.2	59.3	42.8	30.0	54.2	42.3	36.9	54.9	45.0	27.4	61.4	47.6	31.6	55.9
PCO_2	24.4	22.6	25.8	24.1	21.2	26.5	23.2	20.5	26.0	24.1	20.3	25.7	24.8	21.0	25.7
HCO_3	15.8	14.7	17.8	16.3	14.2	17.4	16.1	13.5	17.5	16.2	14.2	18.0	16.3	15.0	17.3
CO_2t	16.6	15.5	18.7	17.1	15.0	16.9	16.9	13.9	18.2	16.9	15.0	18.7	17.1	15.7	18.1
BE	-4.1	-2.7	-6.5	-4.2	-3.0	-6.7	-4.9	-1.9	-6.7	-4.7	-1.9	-6.5	-4.2	-2.5	-5.2

Tab. II. Median, first and third quartile values for the acid-base parameters in capillary fetal blood. Samples collected after fasting at intervals of 15, 30, 45 and 60 minutes after glucose infusion.

A.B.E.	Fasting			15 min			30 min			45 min			60 min		
	M	Q_1	Q_3	M	Q_1	Q_3	M	Q_1	Q_3	M	Q_1	Q_3	M	Q_1	Q_3
pH	7.349	7.297	7.388	7.355	7.285	7.398	7.353	7.287	7.391	7.325	7.300	7.364	7.350	7.318	7.366
pO_2	18.2	15.8	19.8	15.2	13.7	18.9	15.2	12.0	18.1	15.5	13.9	18.1	15.5	13.3	18.1
pCO_2	30.0	22.9	34.4	31.5	24.8	35.6	30.7	26.2	35.0	32.2	28.2	34.8	30.5	27.4	35.0
HCO_3	15.9	11.8	17.5	15.4	14.0	17.1	16.3	14.3	19.0	15.9	14.6	18.3	16.6	13.8	18.1
CO_2t	16.7	12.5	19.5	16.3	15.0	18.1	17.2	15.0	20.0	17.0	15.2	19.3	17.8	14.4	19.1
BE	-4.9	-2.6	-8.2	-5.2	-3.8	-7.2	-5.0	-2.2	-6.5	-2.9	-2.9	-6.4	-4.1	-2.4	-6.3

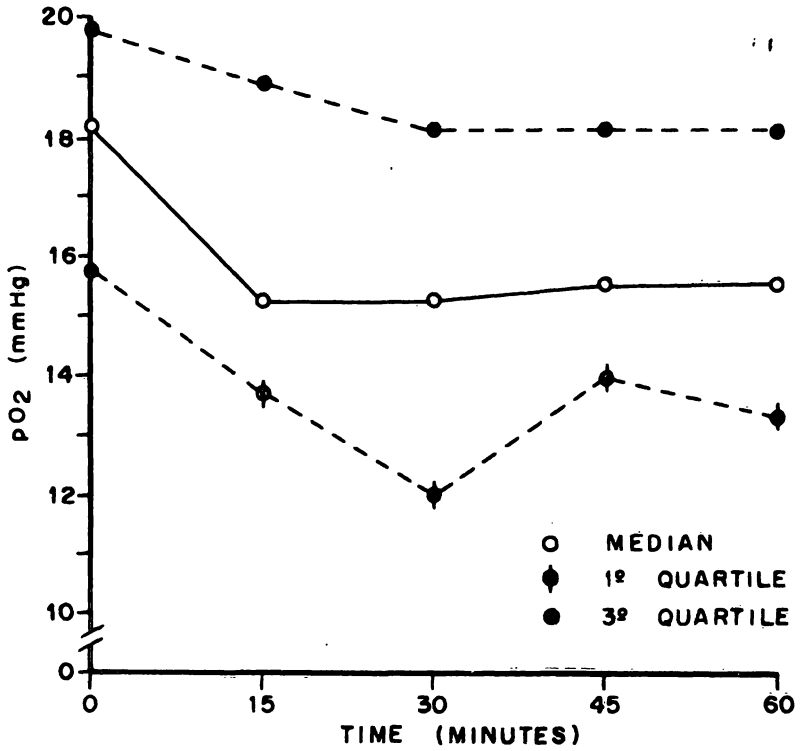

Fig. 1. Median, 1st and 3rd quartile values for pO_2 of capillary fetal blood at the different time points after glucose infusion.

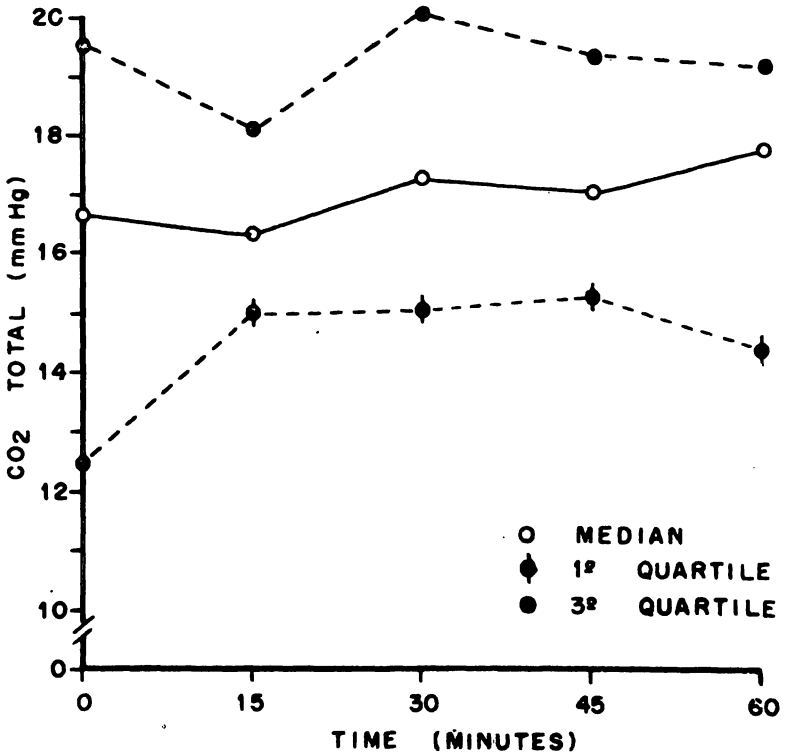

Fig. 2. Median, 1st and 3rd quartile values for total CO_2 of fetal capillary blood at the different time points after glucose infusion.

tends to increase. Thus, it seems that the moment at which the samples were collected should be taken into account when interpreting these results. It is also known that an increase in glycemic levels stimulates the rate of glucose consumption at the expense of its aerobic metabolism, with reduced oxygen and increased CO_2, the latter being one of the final products of this glycolytic pathway [10].

In view of the fact that glucose administration is important therapeutic treatment in acute fetal distress, it would be desirable to reproduce the present study on fetuses with impaired vitality. Such a study would represent an important contribution to obstetrical practice as well as to the study of the physiopathology and treatment of fetal distress.

Summary

The effect of hypertonic glucose infusion on the maternal and fetal acid-base equilibrium was studied in 20 clinically normal parturients and their concepts.
Samples of maternal peripheral venous blood and fetal capillary blood were collected before and after intravenous infusion of 25 g of glucose into the mother at 15-minute intervals. **No significant alterations in the parameters of the maternal acid-base equilibrium were observed.** On the fetal ide, a significant decrease in pO_2 at intervals of 30, 45 and 60 minutes after glucose infusion (fig. 1), and an increase of total CO_2 after 60 minutes (fig. 2) were observed. These findings did not permit us to state that glucose infusion may be responsible for the alterations found, since it is known that as labor progresses. PO_2 tends to decrease while total CO_2 tends to increase. On the other hand, **an increase in glycemic levels is known to stimulate the rate of glucose consumption at the expense of its aerobic metabolism, by reducing the oxygen level and increasing CO_2,** the final products of this glucolytic pathway.

Keywords: Blood gas analysis, carbohydrates, delivery, fetus, glucose, hypertonic solutions, infusions, labor, maternal-fetal, exchange, mothers.

Zusammenfassung

Der Einfluß einer Glucoseinfusion auf den mütterlichen und fetalen Säure-Basen-Haushalt während der Geburt
Wir untersuchten den Effekt einer hypertonen Glucoseinfusion auf das mütterliche und fetale Säure-Basen-Gleichgewicht bei 20 Frauen mit klinisch normalem Geburtsverlauf. Es wurden Blutproben aus einer peripheren Vene der Mutter sowie aus der Kopfhaut des Feten entnommen und zwar in Abständen von 15 min vor, während und nach der Infusion von 25 g Glucose in den mütterlichen Kreislauf. **Dabei beobachteten wir keine signifikanten Veränderungen im Säure-Basen-Haushalt der Mutter.** Beim Feten jedoch registrierten wir einen signifikanten Abfall des pO_2 sowohl 30, 45 wie auch 60 min nach der Infusion (Fig. 1) und einen Anstieg des Gesamt-CO_2 60 min nach der Infusion (Fig. 2). Diese Ergebnisse erlauben aber nicht die Feststellung, daß die Glucoseinfusion für die Veränderungen verantwortlich zu machen ist, denn es ist ja bekannt, daß unter fortschreitender Wehentätigkeit der pO_2 sinkt, während das Gesamt-CO_2 ansteigt. Auf der anderen Seite weiß man, daß ein hoher Glucosespiegel den anaeroben Glucoseabbau stimuliert und zwar auf Kosten des aeroben Abbaus. **Der reduzierte pO_2 und das angestiegene CO_2 lassen sich damit auch durch die erhöhte Glykolyserate erklären.**

Schlüsselwörter: Blutgasanalyse, Entbindung, Fet, Glucose, hypertone Lösungen, Infusionen, Kohlenhydrate, Labor, materno-fetaler Austausch, Mütter.

Résumé

Effet de la perfusion de glucose sur l'équilibre acido-basique maternel et foetal pendant l'accouchement
Les auteurs étudient les effets de la perfusion de glucose hypertonique sur l'équilibre acido-basique maternel et foetal chez 20 parturientes et leurs foetus considérés comme cliniquement normaux. Par voie intra-veineuse ils injectent 25 g de glucose pendant 4 minutes et prélèvent du sang veineux périphérique maternel toutes les 15 minutes après l'injection, pendant une période de 60 minutes et ils observent les modifications des paramètres de l'équilibre acido-basique avant et après l'injection. Les échantillons de sang capillaire foetal et de sang maternel sont prélevés simultanément et étudiés pendant des laps de temps égaux. La technique de prélèvement du sang capillaire au scalp, décrite par SALING [1962], a été appliquée.
Les auteurs n'ont pas observé de modifications significatives parmi les paramètres de l'équilibre acido-basique maternel. Chez le foetus, il a été observé une diminution significative de la pO_2, 45 et 60 minutes après l'injection de glucose (fig. 1) et du CO_2 total après 60 minutes (fig. 2).
Pour les autres paramètres, il n'a pas été observé de différences significatives. Les résultats obtenus ne permettent pas d'interpréter avec certitude les modifications observées lors de l'injection de glucose car il est

bien connu que durant le travail, la pO_2 tend à diminuer et le CO_2 total à augmenter. D'autre part, on sait que l'élévation des niveaux glycémiques stimule la vitesse de consommation du glucose, au prix de sa métabolisation aérobique, ce qui diminue le niveau de l'oxygène et augmente celui du CO_2, produit terminal de cette voie glycolytique.

Mots-clés: Gaz sanguins, glucides, expulsion, foetus, glucose solutions hypertoniques, perfusions, travail, échanges materno-foetaux.

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